MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EOP4066 – OPTICAL COMMUNICATION SYSTEMS

(All sections/Groups)

11th-OCTOBER 2017
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a)

(i) An optical fiber has a numerical aperture (NA) of 0.221 and a cladding refractive index of 1.585, determine the critical angle at the core-cladding interface.

[5 marks]

(ii) A step-index fiber has a core diameter of $100\mu m$ with refractive index of 1.48. If the cladding refractive index of 1.46, calculate the numerical aperture of the fiber and the acceptance angle from air.

[5 marks]

(b) Describe two characteristics of a photodetector that makes it suitable for an optical fiber communication system.

[4 marks]

(c) Figure 1 shows a fiber with a core refractive index of 1.505, a cladding of refrac-Tive index of 1.475 and a core diameter of 25 μm .The fiber is surrounded by air.

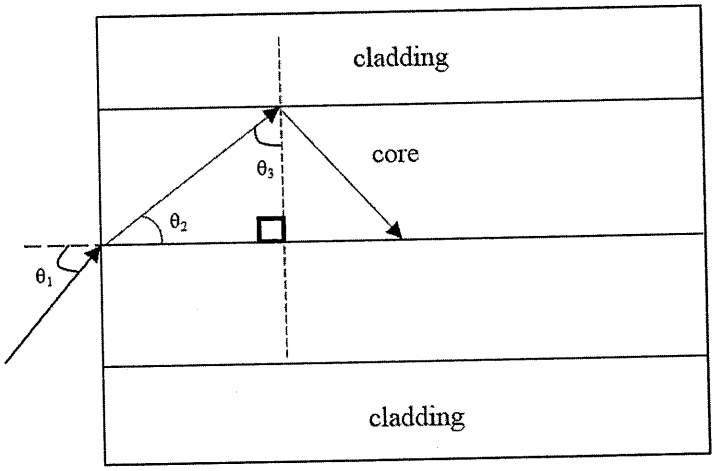

Figure 1

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(i) Calculate the numerical aperture and critical angle θ_3 of the fiber. Assume that the fiber is not bent. [4 marks]

(ii) Calculate the minimum angle θ_1. [4 marks]

(iii) How many modes would propagate in the fiber at a wavelength of 1550 nm? [3 marks]

Question 2

(a) Why is attenuation an important consideration in the design of optical transmission links? [2 marks]

(b) Two types of nonlinear scattering are stimulated Brillouin scattering (SBS) and stimulated Raman scattering (SRS). A single mode fiber has a fiber core diameter of 10 μm at the operating wavelength λ of 1.55 μm, while using an injection laser source of bandwidth as 1.5 GHz. The attenuation α_{dB} is 0.2 dB/km. [Hint: Threshold power of SBS, $P_B = 4.4\times10^{-3}\ d^2\ \lambda^2\ \alpha_{dB}\ V$ watt and threshold power for SRS, $P_R = 5.9\times10^{-2}\ d^2\ \lambda\ \alpha_{dB}$ watt].

(i) Calculate the threshold power for both SBS and SRS. Comment on your answer. [5 marks]

(ii) Describe two differences between SBS (Stimulated Brillouin Scattering) and SRS (Stimulated Raman Scattering). [4 marks]

(c) Describe macrobending loss with proper formula [6 marks]

(d) An optical fiber has an attenuation (resulting from Rayleigh scattering) of 0.45 dB/km at a wavelength of 1.55 μm. Determine the Rayleigh scattering coefficient χ_R of the fiber. [2 marks]

(e) A 20 km optical fiber link consisting of a multimode step index fiber exhibits rms intermodal pulse broadening, $\sigma_{\text{intermodal}}$ of 280 ns and has a relative refractive index difference, Δ of 1%. [Hint: $\sigma_{\text{intermodal}} = \frac{Ln_1\Delta}{2\sqrt{3}\times c}$ where L is length of fiber and c is the speed of light]

(i) Estimate the core refractive index of the fiber, n_1. [2 marks]

(ii) Calculate the maximum bit rate that may be obtained assuming only intermodal dispersion. [2 marks]

(iii) Determine the maximum possible bandwidth on the link assuming RZ coding and the bandwidth-length product of the fiber. [2 marks]

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Question 3

(a) As a network engineer, you are required to design an optical communication system for a wide bandwidth communication system. Propose the preferred optical fiber type and optical source for this network. For the preferred optical source, give two reasons to support your answer. [6 marks]

(b) Describe two differences between a semiconductor laser amplifier and a fiber amplifier. [4 marks]

(c) An optical amplifier has parameter values as shown in Table 1. Calculate the input signal power (in dBm) and the signal-to-noise ratio (in dB) at the amplifier input. [4 marks]

Table 1

Symbol	Parameter	Value
λ	Wavelength	1.55 μm
P_{out}	Output power	20 mW
F	Noise figure	4
G	Gain	25 dB
n_{sp}	spontaneous-emission factor	2
$\Delta\nu_{opt}$	Optical bandwidth	25×10^{11} Hz
SNR_{output}	Signal-to-noise ratio at output	35 dB

(d) Describe the node connection of a star network and a ring network. Your answer should include how messages are transmitted from node to node. Which is the best among these two topologies? Justify your answer. [6 marks]

(e) With the help of a suitable diagram, illustrate and describe the concept of a basic add-drop multiplexed network. Assume there are five end users in the network. [5 marks]

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Question 4

(a) Wavelength division multiplexing (WDM) is a technique that allows multiple channels to be carried in a single optical fiber. As an optical network engineer, propose an optical source, a multiplexer and a demultiplexer that is suitable for a WDM network and justify your answer. [9 marks]

(b) One of the nonlinear effects in a WDM system is due to four wave mixing (FWM).

(i) Name two factors that influence FWM. [2 marks]

(ii) Suggest one method to minimize the impact of FWM. [2 marks]

(c) Two types of digital modulation scheme are non-return-to-zero (NRZ) and return-to-zero (RZ).

(i) Describe these two modulation schemes in terms of the power in a transmit "1" pulse and the bit period. [3 marks]

(ii) Which digital modulation scheme is mainly used in long distance submarine systems? Give ONE (1) reason for this. [3 marks]

(iii) Why does conventional NRZ and RZ system use low intensity pulses? [2 marks]

(d) In network categories describe Local Area Network(LAN) and Wide area Network (WAN). [4marks]

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Appendix A

Physical Constants and Units

Constant	Symbol	Value (mks units)
Speed of light in vacuum	c	3×10^{8} m/s
Electron charge	q	1.602×10^{-19} C
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Permittivity of free space	ε_0	8.8542×10^{-12} F/m
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ N/A^2
Electron volt	eV	1 eV = 1.602×10^{-19} J
Planck's constant	h	6.626×10^{-34} J·s

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